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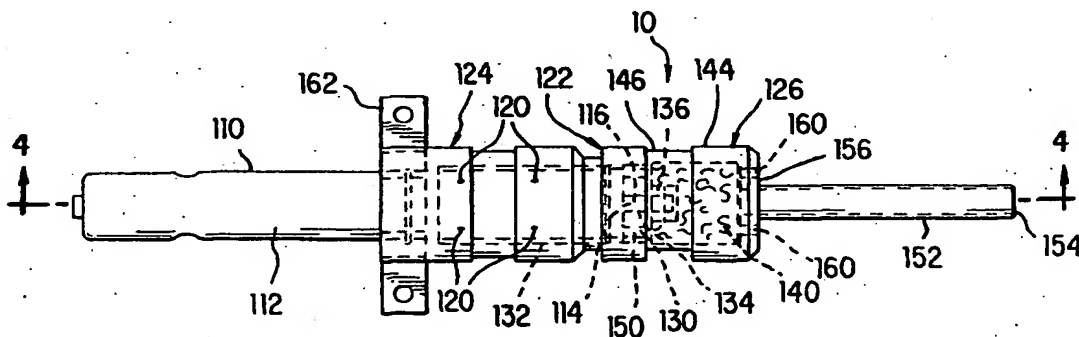
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(54) Title: SIDE IMPACT INFLATOR ASSEMBLY WITH EXTERNAL GAS COOLING



## (57) Abstract

An airbag module assembly and a method for tuning the inflation performance characteristics of such a module which contains a hot gas-producing inflator (110) by placing and housing a selected quantity of a gas cooling medium (140) housed within an inflator housing (122) external to the inflator (110) and in discharge communication therewith whereby hot gas discharged from the inflator (110) contacts the gas cooling medium (140) to form an inflation gas at a reduced second temperature, where the second temperature is substantially less than the first temperature.

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## SIDE IMPACT INFLATOR ASSEMBLY WITH EXTERNAL GAS COOLING

### BACKGROUND OF THE INVENTION

5 This invention relates generally to inflatable passive restraint systems for use in vehicles for restraining the movement of a seated occupant such as in the event of a collision and, more particularly, to assemblies used in such systems to provide occupant protection in the event the vehicle undergoes a sudden side impact form of collision.

10 It is well known to protect a vehicle occupant by means of safety restraint systems which self-actuate from an undeployed to a deployed state without the need for intervention by the operator, i.e., "passive restraint systems." Such systems commonly contain or include an inflatable vehicle occupant restraint or element, such as in the form of a cushion or bag, commonly referred to as an "airbag cushion." In practice, such airbag cushions are typically designed to inflate or expand with gas when the vehicle encounters a  
15 sudden deceleration, such as in the event of a collision. Such airbag cushion(s) may desirably deploy into one or more locations within the vehicle between the occupant and certain parts of the vehicle interior, such as the doors, steering wheel, instrument panel or the like, to prevent or avoid the occupant from forcibly striking such parts of the vehicle interior.

20 Various types or forms of such passive restraint assemblies have been developed or tailored to provide desired vehicle occupant protection based on either or both the position or placement of the occupant within the vehicle and the direction or nature of the vehicle collision. For example, driver side and passenger side inflatable restraint installations have found wide usage for providing protection to drivers and front seat passengers, respectively, in the event of head-on types of collisions. Driver side and  
25 passenger side inflatable restraint installations do not, however, generally provide as great as may be desired protection against vehicular impacts inflicted or imposed from directions other than head-on, i.e., "side impacts." In view thereof, great efforts have been directed to developing inflatable restraint installations having particular effectiveness in the event of a side impact.

30 Upon deployment, the time period during which an airbag cushion remains pressurized is commonly referred to as "stand-up time." In practice, driver side and

passenger side airbag cushions are typically desirably designed to begin deflating almost instantaneously upon deployment such as to avoid presenting an undesirably hard or ungiving surface to an oppositely seated vehicle occupant. However, in the event of certain accidents or collisions, airbag cushions which provide substantially longer stand-up times  
5 may be required or desired in order to provide a suitable desired level of occupant protection.

For example, one particularly troublesome form of side impact is commonly referred to as a "roll-over." In a roll-over incident, a vehicle may undergo a partial, complete or multiple roll-over. As will be appreciated by those skilled in the art, roll-over accidents can be particularly demanding on inflatable restraint systems. In particular, an airbag  
10 cushion designed to provide occupant protection in the event of a vehicle roll-over may be required or desired to remain pressurized for an extended or prolonged period of time, as compared to usual or typical driver side and passenger side airbag installations. For example, a roll-over protection side impact airbag cushion desirably remains pressurized or provides a stand-up time as long as about 5 seconds.

15 One particularly effective form of side impact inflatable restraint is the subject of HÅland et al., U.S. Patent 5,788,270, issued 04 August 1998, the disclosure of which patent is hereby incorporated by reference herein in its entirety and made a part hereof. Inflatable elements, such as disclosed in HÅland et al., U.S. Patent 5,788,270, may desirably include an inflatable portion formed from two layers of fabric with the front layer and the  
20 back layer of the fabric woven together at selected points. In particular embodiments, such selected points are arranged in vertically extending columns and serve to divide the inflatable part into a plurality of vertical parallel chambers. The spaces between the selected points permit internal venting between adjacent chambers of the inflatable element. Particular such inflatable devices/elements, such as utilized in applications to provide protection over an  
25 extended area and having a generally planar form, are frequently referred to as "inflatable curtains."

A one piece woven construction has been found to be a particularly effective method of forming such inflatable element airbag cushions. In particular, one piece woven constructions have been found to provide a relatively low cost method of constructing  
30 suitable such airbag cushions which provide desired stand-up times. While inflatable

element airbag cushions can, as is known in the art, be fabricated of various materials, nylon 6,6 has been found to be a particularly effective and useful material for use in the making or manufacture of inflatable curtain elements such as described above and having a one piece woven design.

5           In addition to an airbag cushion, inflatable passive restraint system installations also typically include a gas generator, also commonly referred to as an "inflator." Upon actuation, such an inflator device desirably serves to provide an inflation fluid, typically in the form of a gas, used to inflate an associated airbag cushion. Many types or forms of inflator devices have been disclosed in the art for use in inflating an inflatable  
10       restraint system airbag cushion.

          One particularly common type or form of inflator device used in inflatable passive restraint systems is commonly referred to as a pyrotechnic inflator. In such inflator devices, gas used in the inflation of an associated inflatable element is derived from the combustion of a pyrotechnic gas generating material. While various combustible  
15       pyrotechnic materials are available, gas generant compositions commonly utilized in the inflation of automotive inflatable restraint airbag cushions have previously most typically employed or been based on sodium azide.

          The gas generated by the combustion of such pyrotechnic materials can be very hot and may contain variously sized particulate material. In practice, it is relatively  
20       common to include within such inflator devices a filter or the like effective to remove such particulate and to reduce the temperature of the gas prior to discharge therefrom. Nevertheless, gas discharge temperatures in the range of about 1300 K are common for conventional pyrotechnic inflator devices. In view thereof, it is common to include within an associated airbag cushion a heat resistant coating or one or more strategically placed  
25       patches of heat resistant material such as to minimize or avoid direct contact of the hot inflator discharge onto unprotected airbag cushion material.

          Another common form or type of inflator device utilizes or relies on a stored compressed gas. Upon actuation, such devices release the stored gas into an associated airbag cushion to effect the inflation thereof. While such inflator devices may reduce or  
30       avoid problems relating to particulate and hot gas discharges, such inflators generally require

the potentially long-term storage of a material under pressure. As will be appreciated, such long-term pressure storage can raise concerns regarding undesirable leakage over the course of the relatively long design lifetimes of such systems once installed in vehicles.

Yet another common form or type of inflator device utilizes or relies on a combination of stored compressed gas and combustion of a gas generating material, e.g., a pyrotechnic, to produce or form an inflation gas for an associated airbag cushion. Such an inflator device is commonly referred to as an augmented gas or hybrid inflator. As with the above-identified pyrotechnic inflators, such inflator devices may result in a gas having an undesirably large or high particulate content. Also, while the discharge from such a hybrid inflator device is generally at a reduced temperature as compared to a corresponding pyrotechnic inflator, the temperature of such discharge may still be undesirably high for certain applications. Further, such inflator devices may suffer from at least some of the possible complications and related concerns regarding the potentially long term storage of a material under pressure.

In practice, an inflator device for use in a particular system installation is designed and sized for that particular installation. As will be appreciated, such design specificity tends to undesirably complicate the assembly and manufacture of such inflator devices and associated inflatable restraint systems. Thus, there is a need and a demand for a suitable arrangement and technique whereby performance characteristics of an inflator device can be tailored to the specifics of a particular installation or inflation event without necessarily requiring the changing or altering of the design or construction of the inflator device. In particular, there is a need and a demand for a relatively simple, effective and low-cost arrangement and technique to so tailor the performance characteristics, e.g., inflation gas flow and temperature, of an inflator device.

In view of the extensive familiarity and experience with hot gas-producing inflator devices such as pyrotechnic-based inflators, there has been a desire to apply or utilize such inflator devices in association with side impact inflatable restraints. Unfortunately, the inclusion of a heat resistant coating or patches of heat resistant material within such inflatable cushion elements is not always practical. For example, such inclusion almost invariably results in the side impact cushion, when folded such as in a stored condition, being

more bulky than is generally desired.

Thus, there is a need and a demand for a side impact airbag module assembly that more easily permits the use of hot gas-producing inflator devices such as pyrotechnic-based inflators.

5 There is also a need and a demand for airbag module assemblies which permit the use of hot gas-producing inflator devices such as pyrotechnic-based inflators in association with inflatable curtain forms of inflatable devices.

Further, there is a need and a demand for a method of tuning the performance of an airbag module assembly, desirably without altering the internal construction of the  
10 associated inflator component.

#### SUMMARY OF THE INVENTION

A general object of the invention is to provide an improved airbag module assembly, particularly for side impact and/or inflatable curtain applications, and method for tuning the performance characteristics of an airbag module assembly.

15 A more specific objective of the invention is to overcome one or more of the problems described above.

The general object of the invention can be attained, at least in part, through a specified side impact airbag module assembly. In accordance with one embodiment of the invention, such a side impact airbag module assembly includes an inflator housing and a hot  
20 gas-producing inflator. The inflator is housed at least in part within the inflator housing. Upon actuation, the inflator discharges a hot gas having a first temperature. The side impact airbag module assembly additionally includes a quantity of a gas cooling medium housed within the inflator housing external to the inflator and in discharge communication therewith whereby the hot gas inflator discharge contacts the gas cooling medium to form an inflation  
25 gas having a reduced temperature, as compared to the hot gas inflator discharge. More particularly, contact of the hot gas inflator discharge with the gas cooling medium forms an inflation gas having a temperature substantially less than the first temperature.

The prior art generally fails to provide an assembly of as simple or effective design as may be desired and such as may better or more easily permit the use of hot  
30 gas-producing inflators, such as pyrotechnic-based inflators, in association with side impact

and/or inflatable curtain inflatable restraint applications. Prior art airbag module assemblies, particularly as relate to side impact installations, also generally fail to provide simple, effective and suitable means by which the performance characteristics of the assembly can be tuned or tailored to a particular installation without altering the internal construction of the associated inflator component.

The invention further comprehends an inflatable curtain airbag module assembly. In accordance with one preferred embodiment, such an assembly includes: an inflator housing, an inflatable curtain airbag, a pyrotechnic inflator and a gas cooling medium housed within the inflator housing external to the pyrotechnic inflator. More particularly, the inflator housing has at least one inflation gas emission opening and the inflatable curtain airbag is in inflation gas receiving fluid communication with the inflator housing. The pyrotechnic inflator is housed, at least in part, within the inflator housing. Upon actuation, the pyrotechnic inflator discharges a gas at a first temperature. The gas cooling medium is in discharge communication with the pyrotechnic inflator whereby gas discharged from the pyrotechnic inflator contacts the gas cooling medium to form an inflation gas at a second temperature, where the second temperature is substantially less than the first temperature.

The invention still further comprehends a method for tuning the output performance of a side impact airbag module assembly. The module assembly includes an inflator housing in inflation gas communication with a side impact airbag cushion. The inflator housing at least in part houses a hot gas-producing inflator. The inflator, upon actuation, produces a hot gas discharge having at least one predetermined characteristic selected from the group of gas flow rate and gas exit temperature at least in part into the inflator housing. The inflator housing in turn emits inflation gas for inflating the side impact airbag cushion. In accordance with one preferred embodiment, such a method involves placing a selected quantity of a cooling medium within the inflator housing in heat transfer communication with the inflator hot gas discharge.

As used herein, references to "side impact" inflatable restraint systems, assemblies and the like are to be understood to generally encompass such systems, assemblies and such as adapted to provide vehicle occupant protection in the event of a side



impact such as by providing one or more of roll-over protection (such as via an inflatable curtain inflation device), head/thorax protection (such as via a head/thorax side impact inflation device) and thorax protection (such as via a thorax side impact inflation device).

Further, references herein to "pyrotechnic-based" inflators and the like are to be understood to refer to those inflator devices which rely in large part on the reaction of a pyrotechnic material to produce an inflation fluid, typically in the form of a gas, for use in the inflation of an associated inflatable device. As will be appreciated, as used herein the broader use of the term "pyrotechnic-based" inflator encompasses both inflators which rely primarily on reaction of a pyrotechnic material to generate or form a desired inflation fluid as well as those inflator devices, such as commonly referred to as "hybrid inflators," which utilize a pyrotechnic material to heat or supplement a stored pressurized gas.

Other objects and advantages will be apparent to those skilled in the art from the following detailed description taken in conjunction with the appended claims and drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a vehicle occupant safety assembly in accordance with one embodiment of the invention.

FIG. 2 is a side view of the interior of a motor vehicle illustrating an inflatable restraint system installation in accordance with one embodiment of the invention.

FIG. 3 is a top plan view of the vehicle occupant safety assembly of FIG. 1.

FIG. 4 is a view taken substantially along the line 4-4 of FIG. 3 and viewed in the direction of the arrows.

FIG. 5 is a detailed cross sectional view of a vehicle occupant safety assembly in accordance with another embodiment of the invention.

FIG. 6 is a view taken substantially along the line 6-6 of FIG. 5 and viewed in the direction of the arrows.

FIG. 7 is a simplified partial sectional view of a vehicle occupant safety assembly in accordance with yet another embodiment of the invention.

FIG. 8 is a perspective view of the inflator housing of the vehicle occupant safety assembly of FIG. 7.

## DETAILED DESCRIPTION OF THE INVENTION

As will be appreciated, the present invention may be embodied in a variety of different structures. Referring initially to FIG. 1, there is illustrated the present invention as embodied in a vehicle occupant safety assembly, also sometimes referred to herein as an inflator assembly, generally designated by the reference numeral 10 and such as adapted for use in association with an inflatable curtain inflatable restraint installation, as described in great detail below.

Turning to FIG. 2, there is illustrated an example of such an inflatable restraint system installation 30 within the interior of a motor vehicle. The restraint system 30 includes the safety assembly 10 and an inflatable curtain safety device 32, such as of the type identified above and described in the above-referenced HÅland et al., U.S. Patent 5,788,270.

The inflatable restraint system 30 and the safety device 32 thereof are intended to provide protection for a person 34 sitting in a seat 36 in the vehicle. In any accident in which the vehicle is decelerated, the person will tend to move forwardly towards the steering wheel 38, but will be restrained by a conventional seat belt or airbag. In the case of a side impact or roll-over, there is a risk that the head of the person 34 may strike either or both the window 39 in the door beside the person, or the vehicle B-pillar 40. There is also a risk that if, as frequently happens, the glass in the window 39 should break, the head of the person 34 may be thrown out of the window opening, especially in the case of a roll-over form of side impact.

The safety device 32, shown in the operative state in FIG. 2, is initially retained in a recess provided in the door frame 42 located above the door of the vehicle. The recess extends over more than simply a linear portion of the door frame so that the two ends of the recess are not in alignment with the main part of the recess.

The safety assembly 10 is adapted to provide a gaseous inflation medium to the safety device 32 to result in the desired inflation thereof. As described in greater detail below, the safety assembly 10 is effective in reducing the temperature of a generated or produced inflation medium to a selected or appropriate temperature for use in such inflation applications.

The safety assembly 10 incorporates, or is associated with, a sensor which senses a side impact and/or a roll-over situation to activate the safety assembly 10 at an appropriate instant. The safety assembly 10 is connected by a hose 46 to a duct 48. The duct 48 forms part of the inflatable curtain safety device 32. The inflatable curtain safety device 32 incorporates a plurality of parallel substantially vertical, substantially cylindrical cells 50. The inflatable element 32 may be made of interwoven fabric. Such a fabric comprises a first layer that defines the front part or region of the inflatable element 32 (e.g., the part of the inflatable element 32 that is visible in FIG. 2) and a second layer that defines the back part or region of the inflatable element 32 (e.g., the part of the inflatable element 32 that is adjacent the window in FIG. 2). Selected areas of the first and second regions in turn are interwoven to define links in the form of points or lines where the front part and the back part of the inflatable element are secured together. A technique for making an inflatable element of interwoven fabric is described in more detail in International Patent Publication WO 90/09295.

A webbing strap 54 that forms part of the inflatable element 32 extends from the end of the inflatable element near the duct 48 which is connected to the hose 46 to an anchoring point 56 on the door frame 42. The edge of the duct 48 is fixed securely to the door frame 42 between the point 60, adjacent the top of the B-pillar 40, and the point 62, at the lower part of the vehicle A-pillar 64, in the region of the dashboard 66. Consequently, it is to be understood that the upper edge of the inflatable element 32 has a nonlinear configuration which conforms with the nonlinear configuration of the upper part of the door frame 42 by virtue of the inflatable element 32 being secured, at an upper edge portion thereof, to the door frame all along a nonlinear part of the door frame as shown in the figures. A substantial part, in fact virtually all, of the upper edge of the inflatable element 32 is secured to the upper part of the door frame 42.

When an accident such as in or of the form of a side impact occurs, the safety assembly 10 generates, produces or forms a hot gas which, in accordance with the invention, is cooled and subsequently passed through the hose 46 to the duct 48, and then inflates the cells 50. The inflatable element 32 thus moves from its initial stored position within the recess in the door frame 42 to the operative position shown in FIG. 2. The inflatable element

32 thus extends downwardly from the top of the door frame 42 to form a generally flat structure located between the head of the person 34 and the adjacent window 39. As the cylindrical cells 50 inflate, the length of the lower edge 70 of the inflatable element 32 is reduced, and thus the lower edge, together with the webbing strap 54 extend substantially  
5 tightly between the point 56 and the point 62.

It is to be noted that the part of the door frame 42 between the points 56 and 62 is not linear, and defines, with the inflated element linear lower edge 70, a generally triangular area which is covered by the inflated element. The inflated element lower edge decreases by about 10% between the uninflated state and the inflated state. The inflated  
10 element is fully inflated within about 25 to about 35 ms. The total thickness of the inflated element is within approximately 60 to 150 mm. The seams of interweaving of the front part and the back part of the inflated element are approximately 30-40 mm apart, so that the resultant cells are cylindrical when inflated. The total volume of gas within the inflated element will typically be in the range of between about 7 and about 30 liters, and the gas may  
15 be at a pressure of about 1 to about 5 bars. The inflated element is not provided with a vent to vent gas from within the element to the atmosphere. Consequently, the inflatable element, when inflated, desirably remains inflated for a relatively long period of time such as to desirably provide protection in the case of a protracted roll-over incident, for example. Moreover, there is venting between at least selected adjacent cells 50, such as may avoid  
20 severe rebound by an occupant to be protected thereby. Thus, if the head of the person in the vehicle impacts with the inflated element, the pressure of gas within the whole element, or at least a substantial part of the element, will rise and thus provide a "soft" impact. If each cell were sealed with no venting of this type, there would be a risk of severe rebound.

The weight of the fabric is desirably kept as low as possible, so that if the  
25 inflatable element should impact with the head of the vehicle occupant as the inflatable element is inflated, no harm will be done. It is thought that a material having a weight of less than 300 g/sq m, such as 175 g/sq m may be used.

It is to be noted that part of the inflated element extends rearwardly beyond the point 60, and is thus located between the head of the person 34 and the top of the B-pillar  
30 40. Thus, the risk of the head of the person impacting with the B-pillar is minimized. Since

the upper edge of the inflatable element is secured to the upper part of the door frame along substantially the whole of its length, there is virtually no risk that the head of the occupant will pass between the upper edge of the inflatable element and the upper part of the door frame, with the head of the occupant of the vehicle thus inadvertently emerging from the body shell of the vehicle.

As will be appreciated, inflatable curtain inflatable elements such as described above can advantageously provide coverage over a large area or zone using an inflatable element of relatively small internal volume. Further, such inflatable curtain inflatable elements can advantageously provide or result in extended stand-up times such as maybe desired to provide more effective occupant protection in the event of a roll-over form of side impact.

Turning now to FIGS. 3 and 4, the safety assembly 10 of FIG. 1 is shown in greater detail. The assembly 10 includes an inflator device, generally designated by the reference numeral 110. The inflator device 110 has a generally tubular shaped body 112 with a lead end 114 forming an inflator attachment screw 116.

The inflator device 110 produces a hot gas, such as described above. Such an inflator device 110 is typically in the form of a pyrotechnic-based inflator such as either an inflator device which relies primarily on reaction of a pyrotechnic material to generate or form a desired inflation fluid or a hybrid inflator, for example.

The inflator device 110 includes a plurality of outlet orifices 120 such as spaced about the perimeter thereof and wherethrough hot gas, such as produced or formed upon actuation of the inflator device 110 and reaction of the pyrotechnic material contained therewithin, is appropriately discharged from the inflator device 110.

The inflator device 110 is housed at least in part in an inflator housing 122. In the illustrated embodiment, the inflator housing 122 is in the form of a multi-piece assembly composed of first and second gas guide chambers 124 and 126, respectively, and such as forms a bulkhead 130 there between. It will be appreciated, however, that the broader practice of the invention is not so limited. For example, a unitary or one piece inflator housing may, if desired, be used. Alternatively, other multi-piece constructions can, if desired, be used.

Further, the inflator housing 122 can be constructed of various materials such as a metal, such as steel or aluminum, or can be designed from a structural plastic such as a nylon or nylon resin such as ZYTEL of E.I. Dupont deNemours Co., for example. In certain preferred embodiments, it can be advantageous to utilize an inflator housing, such as an inflator housing 122, constructed of a plastic material which will melt in the event of a vehicle fire such as in satisfaction of FMVSS 302 relating to bonfire requirements.

As shown, a gas flow gap, designated by the reference numeral 132, is formed between the external surface of the inflator device 110 and the interior of the first gas guide chamber 124. Gas discharged from the inflator device 110 via the outlet orifices 120 is passed into fluid communication with the gas flow gap 132.

The bulkhead 130 desirably includes a central opening 134 such as to permit the passage therethrough of the inflator attachment screw 116. As shown an inflator attachment nut 136 can be applied to the screw 116 such as to further secure attachment of the inflator device 110 within the inflator housing 122.

The second gas guide chamber 126 is joined to the first gas guide chamber 124, such as adjacent the bulkhead 130. The second gas guide chamber 126 houses or contains a quantity of a gas cooling medium, designated by the reference numeral 140. As described in greater detail below, the gas cooling medium 140 desirably serves to cool or otherwise significantly reduce the temperature of the discharge from the inflator device such as to form an inflation gas at a reduced temperature, as compared to the temperature of the gas discharge from the inflator device 110. In practice, such significant temperature reduction typically is desirably in the range of at least about 25 to 50 percent with respect to the discharge of a hot gas-producing inflator such a pyrotechnic-based inflator, i.e., an inflator which primarily relies on reaction of a pyrotechnic material for gas generation. For example, with a pyrotechnic inflator having a gas discharge out of the inflator in the temperature range of about 1300 K, the practice of the invention desirably results in cooling of the gas to an assembly exit temperature of about 700 to about 1100 K. In accordance with the invention and as described in greater detail below, the gas cooling medium 140 can take various forms such as including either or both mechanical and chemical cooling media as may be desired and particularly suited for specific applications of the invention.

As will be appreciated, the gas pressure within an inflatable restraint device is dependent on various factors including, for example, the temperature and volume of gas used for the inflation thereof. When a hot gas is used to inflate an inflatable element, the pressure within the element will naturally decrease as the gas cools. In view thereof, practice of the invention wherein the generated hot gas is cooled prior to passage into the associated inflatable restraint element, desirably reduces the effect of inflation gas pressure reduction associated with the ultimate cooling of the inflation gas to ambient or near ambient conditions. As a result of the invention, the pressure within an associated inflatable element can be desirably maintained for a longer period of time and the invention can serve to provide extended stand-up times such as may be desired in the event of a vehicle roll-over.

The inflator housing 122 forms or includes, such as at the outer surface 144 of the second gas guide chamber 126, an airbag retainment ring 146 such as to permit or facilitate the mechanical locking of an associated inflatable device, such as the inflatable curtain 32 shown in FIG. 2, to the safety assembly 10. In accordance with the broader practice of the invention, however, it will be understood that other suitable alternative airbag attachment or joining methods or techniques, such as are known in the art, can be used.

As shown, the bulkhead 130 desirably includes one or more holes or openings 150 permitting gas flow communication between the gas flow gap 132 formed in the first gas guide chamber 124 and the gas cooling medium 140 stored or contained within the second gas guide chamber 126. In the illustrated embodiment, the bulkhead 130 includes 6 such holes or openings, only 2 of which are visible in each of the views of FIGS. 3 and 4, respectively.

Formed continuous with the second gas guide chamber 126 and extending therefrom is a flute 152. The flute 152 forms an inflation gas discharge outlet 154 such as to permit the passage of inflation gas from the assembly 10 and such as into an associated inflatable device, such as the inflatable curtain 32 shown in FIG. 2.

The lead wall 156 of the second gas guide chamber 126 also includes a plurality of gas exit holes 160, such as spaced about the flute 152. As will be appreciated, inflation gas formed upon passage of discharge from the inflator device 110 through the gas cooling medium 140 in the second gas guide chamber 126 is additionally discharged through

these gas exit holes 160.

The safety assembly 10 also includes a mounting flange 162 such as positioned at or about the inflator housing 122 to permit or facilitate the attachment or mounting of the assembly 10 to or within an associated vehicle. In accordance with the  
5 broader practice of the invention, however, it will be understood that other suitable alternative attachment techniques and devices, such as known in the art, can be used such as to permit or facilitate the attachment, mounting or placement of such an assembly within or to an associated vehicle.

Thus, the inflator housing 122 advantageously serves to direct the flow of  
10 inflation gas into the associated airbag cushion (not shown). Further, the inflator housing 122 also advantageously serves to channel or direct the discharge from the inflator device 110 through the cooling medium 140.

As will be appreciated, the gas flow in the safety assembly 10 is generally maintained in an axial direction relative to the elongated inflator device 110. Such an axial  
15 flow arrangement is particularly suited for use in connection with an inflatable restraint system installation such as shown in FIG. 2 wherein such a safety assembly can be generally aligned with an associated inflatable device.

In accordance with certain preferred embodiments of the invention, the cooling medium of such inflator assemblies is advantageously positioned or placed in the  
20 path of the hot gas exiting from the associated inflator device such that the hot gas is in heat transfer communication therewith. More particularly, the hot gas may directly contact or pass through such cooling medium in heat transfer relationship such that the hot gas is significantly cooled. In practice, cooling of such hot gases to temperatures of about 0.75 to about 0.5 of the original generated temperature can be advantageously realized through the  
25 practice of the invention.

FIG. 5 is a detailed cross sectional view of an airbag safety or inflator assembly 210 in accordance with another alternative embodiment of the invention.

The assembly 210 includes an inflator 212 housed or contained within an inflator housing 214. The inflator 212 is held or retained within the inflator housing 214 by  
30 means of a crimp 216 in association with an O-ring or other suitable seal member 218, such



as adjacent the end 220 of the inflator housing 214. It will be understood, however, that the broader practice of the invention is not so limited. For example, other suitable connection means or techniques, such as are known in the art can, if desired, be used.

5 The inflator 212 has a generally tubular body portion 222 and includes or is operationally connected to a squib 224 or other suitable initiation device. Upon receipt of a proper activating signal such as from associated sensors (not shown), the squib 224 acts to initiate gas generating reaction or release from the inflator 212. To that end, the inflator housing 214 has an end opening 226 to permit such signal receiving connection or joinder to the inflator 212, particularly the squib portion 224 thereof.

10 The inflator 212 also includes a plurality of outlet orifices 230 wherethrough hot gas, such as produced or formed upon actuation of the inflator 212 and reaction of the pyrotechnic material contained therewithin, can be appropriately discharged. In the illustrated embodiment, the outlet orifices 230 are desirably radially spaced and arranged about the tubular body portion 222 thereof such as to desirably reduce, minimize or avoid  
15 the creation of unbalanced gas discharge forces upon actuation of the inflator 212.

The inflator housing 214 forms a gas guide chamber 232 having an inner diameter 234 which is greater than the outer diameter 236 of the inflator tubular body portion 222, thus forming a gas flow gap 240 therebetween. As with the gas flow gap 132 in the above-described embodiment, the gas flow gap 240 permits fluid communication and  
20 passage of the hot gas discharge from the associated inflator device housed or stored within the respective housing.

The inflator housing 214 also forms a coolant storage volume 242 adjacent the inflator end 244. Similar to the above-described embodiment and as described in greater detail below, the coolant storage volume 242 contains a suitable quantity of a selected gas  
25 cooling medium 246 effective to cool or otherwise significantly reduce the temperature of the discharge from the inflator device 212 such as to form an inflation gas at a reduced temperature, as compared to the temperature of the gas discharge from the inflator device 212.

An exit nozzle 250 can be formed as an extension of the gas guide chamber  
30 232 or, as shown, joined thereto. More particularly, the gas guide chamber 232 forms a neck

region 252 which is joined or secured to the exit nozzle 250. Desirably, within the exit nozzle 250 there is formed or included a restricted passage or other suitable retainer device 254 such as can serve to ensure that gas cooling medium 246 is not undesirably passed along with the inflation gas, from the coolant storage volume 242 through the exit nozzle 250.

5 If desired and as shown, the exit nozzle 250 may include or have formed thereon a lip portion 256 such as can serve to facilitate retention of an associated airbag cushion, such as is known in the art. Further, suitable attachment mounting such as the mountings 260a and 260b may be formed as a part of the assembly or included therewith to permit the desired attachment of the assembly such as within a selected vehicle.

10 Still further, as shown in FIG. 5 and the cross sectional view shown in FIG. 6, the inflator housing 214 may have formed therein suitable centering dimples, designated by the reference numeral 262, such as to help ensure proper centering of the inflator device 212 within the inflator housing 214 and such as may assist in ensuring a more uniform gas flow in the gas flow gap 240. As will be appreciated, the broader practice of the invention  
15 is not so limited and, if desired, other suitable techniques or means such as know to those skilled in the art can be used.

Turning now to FIG. 7, there is illustrated a vehicle occupant safety assembly 310, such as adapted for use in association with a head/thorax side impact inflatable restraint such as generally known in the art. The assembly 310 includes an inflator device, generally  
20 designated by the reference numeral 312. The inflator device 312 has a generally elongated tubular shaped body 314 with a lead end 316 and a base end 320.

The inflator device 312 produces a hot gas, such as described above. Such an inflator device 312 is typically in the form of a pyrotechnic-based inflator such as either an inflator device which relies primarily on reaction of a pyrotechnic material to generate or  
25 form a desired inflation fluid or a hybrid inflator, for example.

More specifically, the inflator device 312 includes a pyrotechnic gas generant-containing portion 322, such as adjacent the lead end 316, and an initiator or squib portion 324, such as adjacent the base end 320. In practice, the squib portion 324 houses or contains a suitable initiator or squib such as known in the art and effective upon actuation  
30 to initiate reaction of a pyrotechnic gas generant material such as known in the art and

housed or contained within the gas generant-containing portion 322. The inflator device 312 includes radial crimps 326 such as may serve to separate the initiator portion 324 from the gas generant-containing portion 322 and thus in turn separate the gas generant material from the initiator material.

5           The inflator device 312 additionally includes a plurality of outlet orifices 330 such as spaced about the perimeter thereof and wherethrough hot gas such as produced or formed upon actuation of the inflator device 312 and reaction of the pyrotechnic material contained therewithin. In the embodiment illustrated in FIG. 7, the inflator device 312 includes 8 such outlet orifices, two of which are visible in FIG. 7. The balance of the outlet  
10          orifices are generally equally spaced about the perimeter thereof the inflator device 312.

          The inflator device 312 is housed or generally contained in an associated inflator housing 336, such as in a generally hollow tubular form having a corresponding elongated shape. The inflator housing 336 additionally includes or has formed therein first and second radial inflator insertion crimps 338a and 338b, respectively, and a safety end  
15          crimp 340 whereby the inflator device can be effectively secured therewithin. As will be appreciated, such radial and end safety crimps can serve to hold the inflator device in place within the assembly such as to minimize or avoid rattle within or by the assembly, such as when the assembly is placed in position within an associated vehicle.

          Further, such radial crimps can also advantageously guide, arrange or place  
20          the inflator device within the housing such as to facilitate a more even or uniform flow of the gaseous discharge from the inflator device. More specifically, a gas flow gap, designated by the reference numeral 342, is formed between the external surface of the inflator device 312 and the interior of the inflator housing 336. Thus, gas discharged from the inflator device 312 via the outlet orifices 330 is passed into fluid communication with the gas flow gap 342.

25          The inflator housing 336 also includes a cooling medium storage volume 344. The cooling medium storage volume 344 houses or contains a selected quantity of a gas cooling medium, designated by the reference numeral 346. The gas cooling medium 346 is in fluid communication with the gas flow gap 342 and, upon actuation of the assembly 310, the discharge of the inflator device 312 passing therethrough. As described above, gas  
30          cooling media useful in the practice of the invention desirably serve to cool or otherwise

significantly reduce the temperature of the discharge from the associated inflator device such as to form an inflation gas at a reduced temperature, as compared to the temperature of the gas discharge from the inflator device. Further, such gas cooling media can take various forms such as including either or both mechanical and chemical cooling media as may be desired and particularly suited for specific applications of the invention.

In FIG. 7, the cooling medium 346 is illustrated in the form of a compressed metal wire spacer. The cooling medium can be adjacent and in contact with the associated inflator device or, as shown, appropriately spaced therefrom. In addition, an end closure 350 serves to close the end of the inflator housing 336 opposite the safety end crimp 340 and to contain or fix the compressed metal wire spacer cooling medium 346 within the inflator housing 336. As will be appreciated, the quantity and density of the cooling medium 346 contained within the storage volume 344 can be appropriately selected such as to provide the appropriate or desired extent or degree of cooling to the discharge from the associated inflator device 312 in addition the cooling medium 346 can be appropriately selected to appropriately slow the flow rate of the inflation gas into the associated inflatable restraint.

As shown in FIG. 8, the inflator housing 336 includes an array of inflation gas emission openings or exit holes 352 wherethrough inflation gas having appropriately reduced temperature, flow rate or both is emitted to an associated thorax or head/thorax side impact inflatable restraint cushion.

The gas flow in and from the vehicle occupant safety assembly 310 initially involves a hot gas being discharged radially from the inflator 312. The inflator discharge is then passed axially (relative to the elongated inflator device 312) through the inflator housing 336, e.g., in the gas flow gap 342. Finally, the desirably treated inflation gas is discharged from the assembly 310 in a generally radial direction relative to the associated inflator device. As will be appreciated, a so directed discharge flow may find particular utility with typical thorax and head/thorax protection inflatable restraints.

Further, suitable attachment mounting such as attachment studs 354 or the like may be included or joined to the inflator housing 336 to permit the desired attachment of the assembly, such as within a selected vehicle.

As identified above, gas cooling media which can be used in the practice of

the invention can take various forms such as including either or both mechanical and chemical cooling media as may be desired and particularly suited for specific applications of the invention.

For example, an inflator assembly in accordance with the invention may incorporate a mechanical cooling medium such as in the form of one or more of a rolled screen such as of heat conductive metal (e.g., steel or copper), expanded metal, thermal ceramic paper and woven wire mesh. Such mechanical cooling media typically desirably have a relatively high thermal conductivity as well as large surface area and mass with which to absorb heat and thus may serve as a heat sink. In practice, however, various factors may serve or act to control or limit the amount of cooling which may be realized through the use of such mechanical cooling means. For example, the amount of cooling realizable through such use of a mechanical cooling means will typically be limited by factors such as the length of time the generated gas is in contact with the cooling media as well as the physical properties or parameters, such as mass, surface area, melt temperature and thermal conductivity of the cooling media.

Thus, the external cooling of hot gas exiting from an inflator device, in accordance with certain preferred embodiments of the invention, relies on and utilizes a relatively light weight mechanical cooling medium which does not significantly adversely affect assembly weight yet provides a dramatic decrease in temperature and thus pressure of the gas issuing forth from the assembly without detrimentally reducing the moles or volume of gas. Further, the utilization of such an external mechanical cooling medium though desirably creating a tortuous path for the passage of the hot gas exiting from the inflator preferably does not choke gas flow to an extent that would adversely affect the speed of deployment of the associated inflatable cushion or the volume of gas provide to result in desired occupant protection.

Alternatively or in addition to the incorporation of such a mechanical cooling medium, inflator assemblies in accordance with the invention may rely on the chemical cooling of generated gases. Chemical cooling of generated gases in accordance with one preferred embodiment of the invention utilizes one or more endothermically reactable chemical coolant materials with which hot generated gases come into contact such that the

hot generated gases are cooled. As will be appreciated, various chemical coolant materials are known and are available for use in the practice of the invention including, for example, various metal carbonates. Magnesium carbonate is one common metal carbonate useful in such applications. The broader practice of the invention, however, is not limited by the specific chemical coolant selected and used therein.

Moreover, it will be appreciated that, if desired, the invention can be practiced using variously shaped and sized forms of chemical coolant. For example, the chemical coolant used in the broader practice of the invention can be in the form of tablets, pellets, crystals or the like as well as various forms or shapes including various extruded forms including cylindrical perforated solids, e.g., solids which include a cylindrical bore such that the coolant solids generally tubular in shape or form.

In addition to providing cooling of hot generated gases which come into contact therewith, at least certain of such chemical coolant materials may advantageously produce or form additional gaseous products upon contact with and cooling of the hot generated gases and such as may be used to supplement the gaseous inflation products issuing forth from the associated inflator device.

In view of the above, it will be understood that the invention advantageously cools the hot gas produced or formed by an inflator externally to the inflator itself. Thus, the gas temperature and thus the gas flow issuing forth from an inflator assembly in accordance with the invention can be tuned or tailored to the needs and specifications of a particular application without necessitating costly and sometimes difficult or complicated alteration of the design or engineering of the inflator device itself. For example, the generant and ignition loads of an inflator can be kept constant and the performance of the assembly containing such an inflator can be tuned by applying either more or less grams of the chemical or mechanical cooling medium. Further, the gas flow rate issuing forth from the inflator assembly can be tuned by varying the geometric shape or form of the cooling medium. For example, denser or less dense forms of a mechanical cooling medium can be employed to restrict or alternatively free the flow of the gas into an associated inflatable device. The ability to use a single generic inflator device for various or multiple performance applications can provide or result in significant cost savings.

Further, the ability of applying external cooling of hot inflator-produced gases to manageable levels can serve to make such hot gas-producing inflators a more practical choice for various additional possible inflator applications, including a feasible alternative to stored gas inflator technologies in certain applications including side impact applications.

5           Thus, the invention generally provides a simpler, more effective inflator assembly such as may desirably permit the greater or more widespread use of hot gas-producing inflators, such as pyrotechnic-based inflators, in association with side impact and/or inflatable curtain inflatable restraint applications. The invention also generally provides simple, effective and suitable means by which one or more inflation performance  
10 characteristics, such as inflation gas flow rate and temperature, for example, can be tuned or tailored to the specific needs of a particular installation without altering the internal construction of the associated inflator component.

Also, the invention provides a relatively simple and effective technique by which the gas flow can be properly redirected such as dependent on the type or form of  
15 inflatable restraint used in association therewith. For example, axial gas flow can be provided for use in conjunction with inflatable restraints in the nature of inflatable curtains. On the other hand, generally radial flow can be provided for use in conjunction with thorax and head/thorax inflatable restraints.

The invention illustratively disclosed herein suitably may be practiced in the  
20 absence of any element, part, step, component, or ingredient which is not specifically disclosed herein.

While in the foregoing detailed description this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purposes of illustration, it will be apparent to those skilled in the art that the invention is  
25 susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the invention.

What is claimed is:

1. A side impact airbag module assembly comprising:  
an inflator housing,  
5 a hot gas-producing inflator, said inflator housed at least in part within said inflator housing, said inflator, upon actuation, discharging a hot gas at a first temperature, and  
a quantity of a gas cooling medium housed within said inflator housing external to said inflator and in discharge communication with said inflator whereby hot gas  
10 discharged from said inflator contacts said gas cooling medium to form an inflation gas at a reduced second temperature, where the second temperature is substantially less than the first temperature.
2. The side impact airbag module assembly of claim 1 wherein said gas  
15 cooling medium comprises a mechanical cooling medium.
3. The side impact airbag module assembly of claim 2 wherein the mechanical cooling medium comprises a metal mesh.
- 20 4. The side impact airbag module assembly of claim 1 wherein said gas cooling medium comprises a chemical cooling medium.
5. The side impact airbag module assembly of claim 4 wherein the chemical cooling medium comprises at least one metal carbonate.
- 25 6. The side impact airbag module assembly of claim 1 wherein said hot gas-producing inflator comprises a pyrotechnic-based inflator.
- 30 7. The side impact airbag module assembly of claim 1 wherein said hot gas-producing inflator comprises a hybrid inflator.



8. The side impact airbag module assembly of claim 1 additionally comprising an inflatable curtain airbag cushion.

5 9. The side impact airbag module assembly of claim 1 additionally comprising an inflatable head/thorax airbag cushion.

10 10. The side impact airbag module assembly of claim 1 additionally comprising a thorax airbag cushion.

10 11. An inflatable curtain airbag module assembly comprising:  
an inflator housing having at least one inflation gas emission opening;  
an inflatable curtain airbag in inflation gas receiving fluid communication  
with said inflator housing;

15 a pyrotechnic inflator, said inflator housed at least in part within said inflator housing, said pyrotechnic inflator, upon actuation, discharging gas at a first temperature; and  
a gas cooling medium housed within said inflator housing external to said pyrotechnic inflator and in discharge communication with said pyrotechnic inflator whereby gas discharged from said pyrotechnic inflator contacts said gas cooling medium to form an inflation gas at a second temperature, where the second temperature is substantially less than  
20 the first temperature.

12. The inflatable curtain airbag module assembly of claim 11 wherein said gas cooling medium comprises a mechanical cooling medium.

25 13. The inflatable curtain airbag module assembly of claim 12 wherein the mechanical cooling medium comprises a metal mesh.

14. The inflatable curtain airbag module assembly of claim 11 wherein said gas cooling medium comprises a chemical cooling medium.

15. The inflatable curtain airbag module assembly of claim 14 wherein the chemical cooling medium comprises at least one metal carbonate.

5 16. In a side impact airbag module assembly wherein an inflator housing is in inflation gas communication with a side impact airbag cushion, the inflator housing at least in part housing a hot gas-producing inflator which upon actuation produces a hot gas discharge having at least one predetermined characteristic selected from the group consisting of gas flow rate and gas exit temperature at least in part into the inflator housing which in turn emits inflation gas for inflating the side impact airbag cushion, a method for tuning the  
10 output performance of the module comprising:

placing a selected quantity of a gas cooling medium within the inflator housing in heat transfer communication with the inflator hot gas discharge.

15 17. The method of claim 16 wherein said gas cooling medium comprises a mechanical cooling medium.

18. The method of claim 17 wherein the mechanical cooling medium comprises a metal mesh.

20 19. The method of claim 16 wherein said gas cooling medium comprises a chemical cooling medium.

20. The method of claim 19 wherein the chemical cooling medium comprises at least one metal carbonate.

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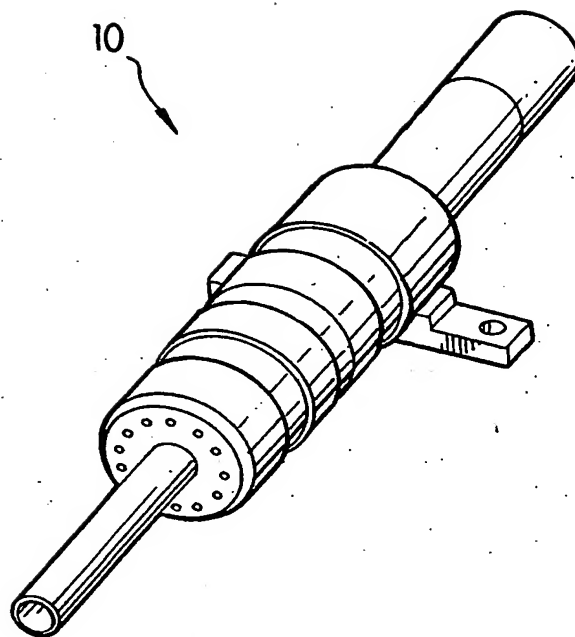


FIG. 1

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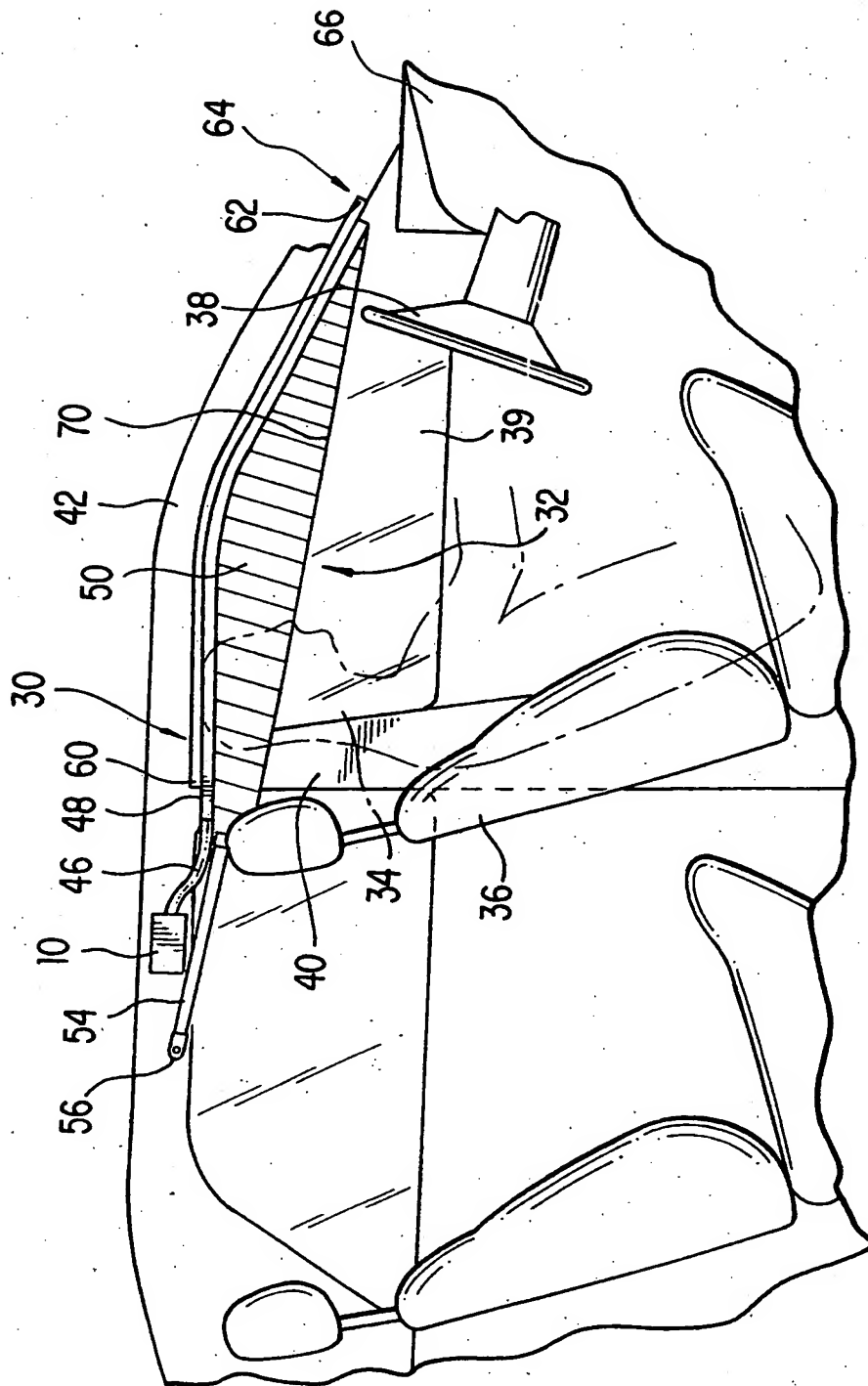
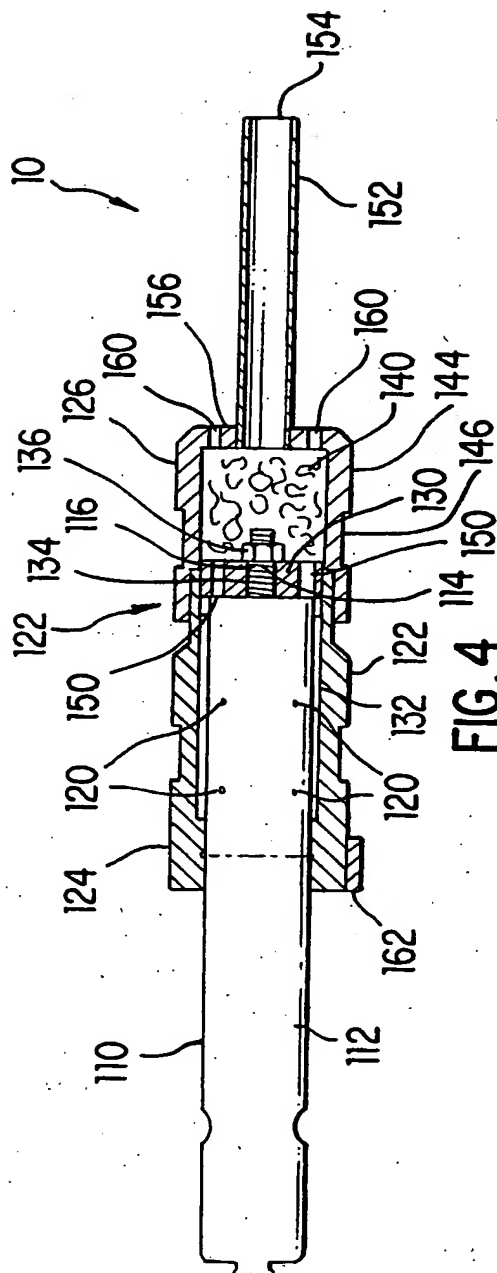
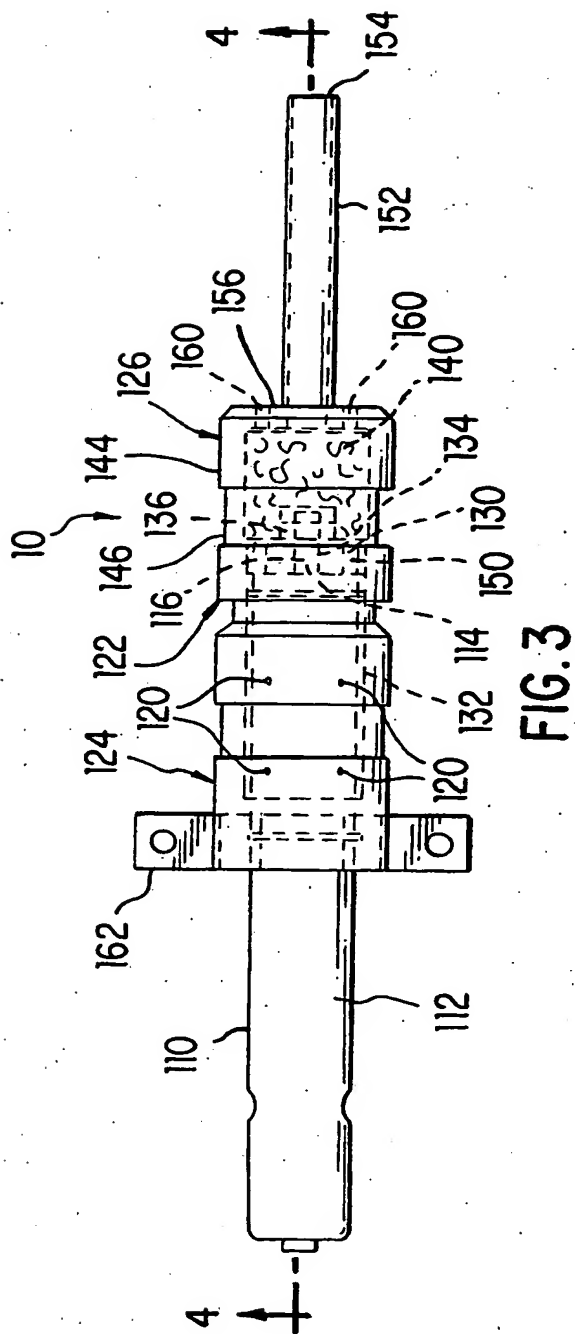


FIG. 2



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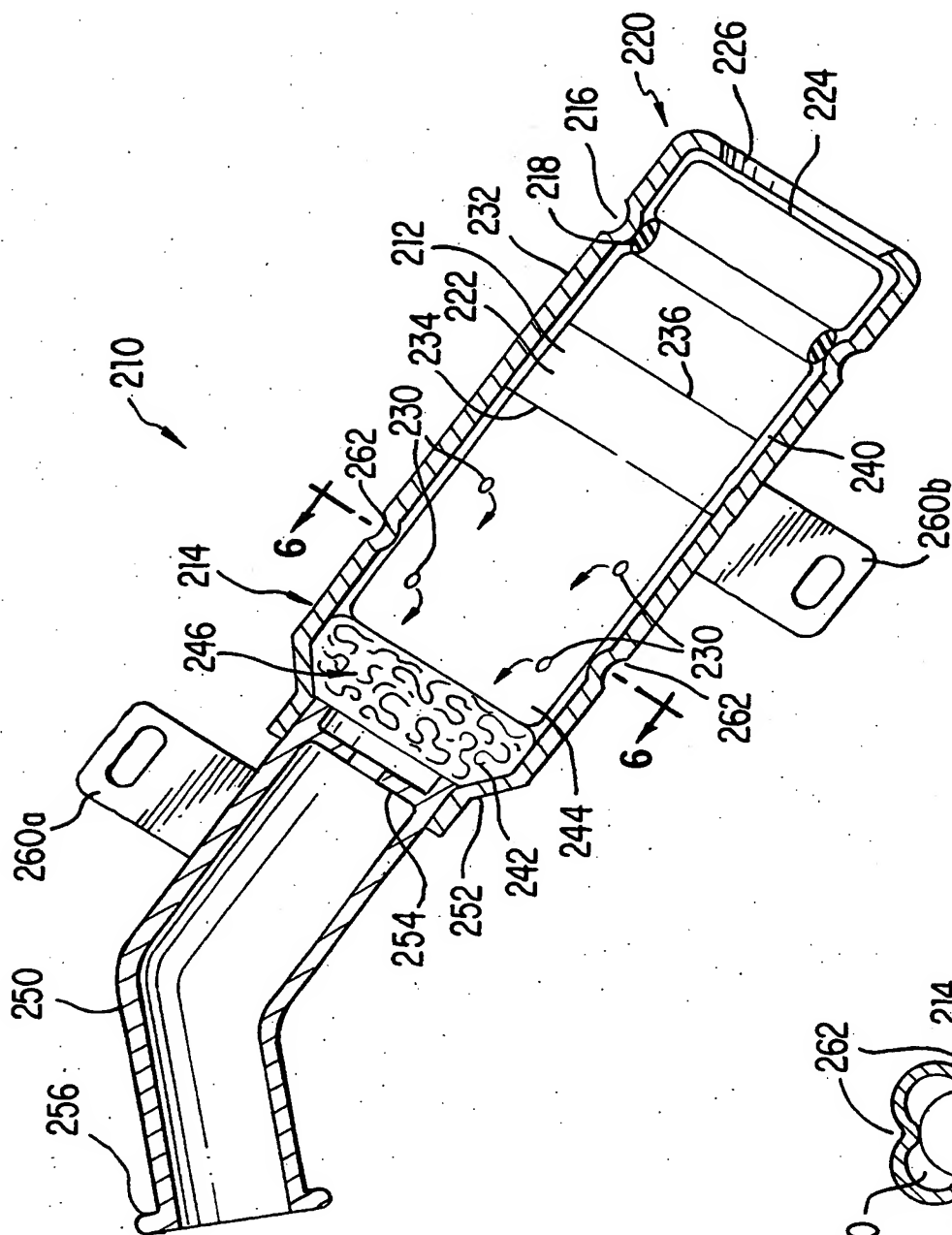


FIG. 5

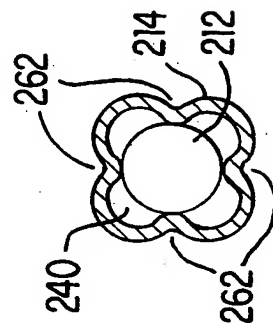


FIG. 6

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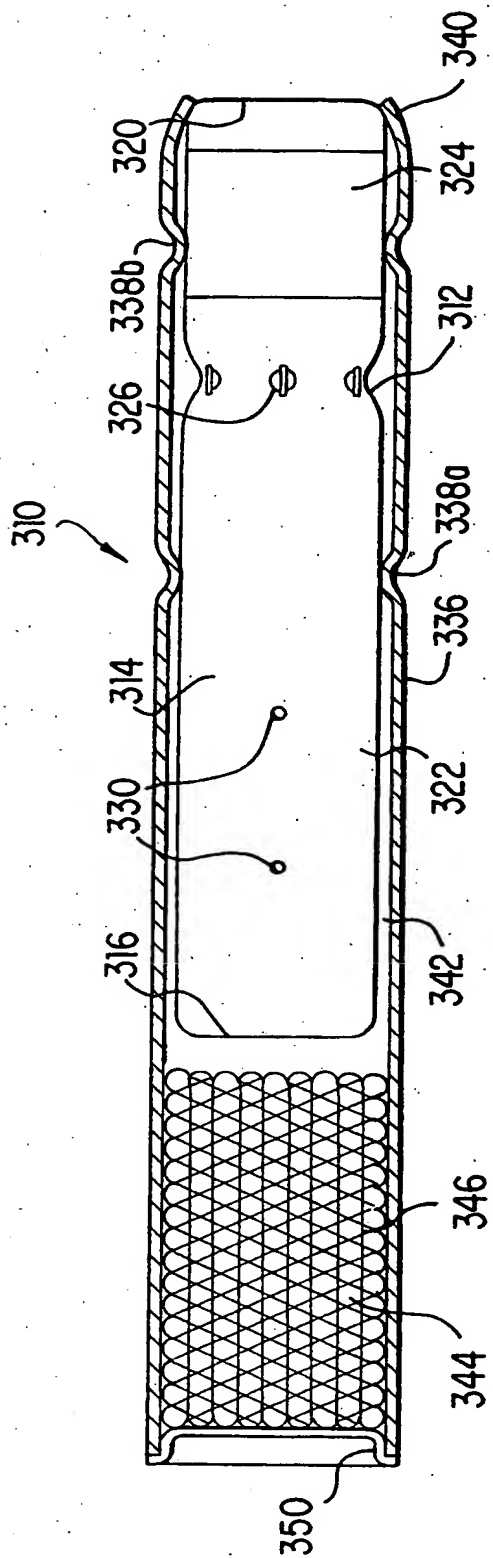


FIG. 7

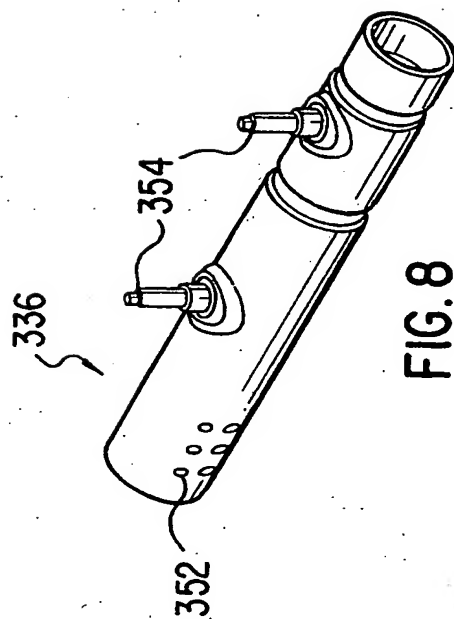


FIG. 8

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/13568

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B60R21/26 B60R21/16

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 005 876 A (JORGENSEN HOWARD E ET AL) 1 February 1977 (1977-02-01)  the whole document	1,2,5,6, 8-12,16, 17
Y	US 5 788 270 A (VALKENBURG SIMOMN ET AL) 4 August 1998 (1998-08-04) cited in the application column 3, line 16-21; figure 1	1,2,5,6, 8-12,16, 17
A	US 4 316 874 A (KASAMA TSUNEO ET AL) 23 February 1982 (1982-02-23) abstract	1,2,12, 17
A	EP 0 897 839 A (DAICEL CHEM) 24 February 1999 (1999-02-24) column 5, line 4-52	3,13,18
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
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- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
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Date of the actual completion of the international search

25 August 2000

Date of mailing of the international search report

05/09/2000

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# INTERNATIONAL SEARCH REPORT

Internal Application No

PCT/US 00/13568

## C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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XCID: <WO\_\_0069690A1\_IA>

## AMENDED CLAIMS

[received by the International Bureau on 3 November 2000 (03.11.00);  
new claims 21-23 added; remaining claims unchanged (2 pages)]

16. In a side impact airbag module assembly wherein an inflator housing is in inflation gas communication with a side impact airbag cushion, the inflator housing at least in part housing a hot gas-producing inflator which upon actuation produces a hot gas discharge having at least one predetermined characteristic selected from the group consisting of gas flow rate and gas exit temperature at least in part into the inflator housing which in turn emits inflation gas for inflating the side impact airbag cushion, a method for tuning the output performance of the module comprising:

placing a selected quantity of a gas cooling medium within the inflator housing in heat transfer communication with the inflator hot gas discharge.

17. The method of claim 16 wherein said gas cooling medium comprises a mechanical cooling medium.

18. The method of claim 17 wherein the mechanical cooling medium comprises a metal mesh.

19. The method of claim 16 wherein said gas cooling medium comprises a chemical cooling medium.

20. The method of claim 19 wherein the chemical cooling medium comprises at least one metal carbonate.

21. The side impact airbag module assembly of claim 1 having said gas cooling medium housed within said inflator housing axially external to said inflator and wherein said inflator housing directs the hot gas discharge from said inflator in an axial direction relative to said inflator.

22. The inflatable curtain airbag module assembly of claim 11 having said gas cooling medium housed within said inflator housing axially external to said pyrotechnic inflator and wherein said inflator housing directs the gas discharge from said pyrotechnic inflator in an axial direction relative to said pyrotechnic inflator.

23. The method of claim 16 wherein the selected quantity of a gas cooling medium is placed within the inflator housing axially external the hot gas-producing inflator.

**Statement Under Article 19**

Claims 21-23 have been added to more fully and completely claim the disclosed subject matter.